

Effectiveness of intraoral suction systems and aspirating tips for evacuation of aluminum oxide particles during use of air-abrasion

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Abstract

Aim: The purpose of this study was to compare the effectiveness of a high-volume evacuation and a conventional intraoral suction system and aspirating tips for capturing aluminum oxide particles during use of an air-abrasion device. **Methods:** A phantom head was fixed at the dental chair head with secured a metallic device with 5 horizontal shafts, corresponding to operator's clock-related working positions, and one vertical shaft to simulate the operator's nasal cavity. Petri plates were fixed to the shafts at distances of 20, 40 and 60 cm from the center of the oral cavity of the phantom head to collect the aluminum oxide particles spread over during air abrasion. The dust was aspirated with two types of suction tips used with both suction systems: a conventional saliva ejector and a saliva ejector customized by the adaptation of a 55-mm-diameter funnel. **Results:** The amount of particles showed that the greatest abrasive particle deposition occurred at a distance of 20 cm from the center of the oral cavity of the phantom head at 9 o'clock operatory position with the conventional saliva ejector attached to high-volume evacuation system. **Conclusions:** The greatest deposition of aluminum oxide particles occurred at the shortest distance between the operator and the center of the oral cavity, while using the high-volume evacuation system associated to the conventional suction tip.

Keywords: air abrasion, dental vacuum systems, aluminum oxide powder.

Introduction

Air-abrasion devices employ a high-speed stream of purified aluminum oxide particles delivered by air pressure and are intended to abrade mineralized dental tissues. Although it is not advised for every clinical procedure, air-abrasion technology has been recommended for removal small carious lesions that require minimally invasive interventions¹⁻².

A usual concern regarding the use of air-abrasion devices is the high environmental contamination produced by the aluminum oxide particle stream. Unlike the aerosol produced by high-speed handpieces, air-abrasion units produce a dry aerosol composed essentially by aluminum oxide powder that not only contaminates the environment, but also spreads over the surrounding surfaces within the operating field and deposit on the dentist's and patient's body and clothes³.

Biosecurity is an area of particular importance in medical and dental fields. Some precautions are required for the use of air-abrasion units in order to prevent or reduce aerosol spreading. The use of protective barriers, such as masks and eyewear, is mandatory to minimize aluminum-oxide particle inhalation and contact with both the operator and auxiliary personnel. A more secure use of air-abrasion

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technology is provided with the concomitant use of suction systems for evacuation of aluminum oxide particles before they can spread over the operating area³⁻⁴.

Reports of the contamination within closed environments are on top of a series of studies to identify and assess the several factors that might influence air quality and it is well-known that the use of air-abrasion devices creates a cloud of particles in the dentist's working field⁵⁻⁷.

The purpose of this study was to compare the effectiveness of a high-volume evacuation and a conventional intraoral suction system and aspirating tips for capturing aluminum oxide particles during use of an air-abrasion device.

Material and methods

Two suction systems were evaluated in this study: a high-volume evacuation system (Ciclone®; Dabi Atlante, Ribeirão Preto, SP, Brazil; motor power: 1HP, water consumption: 0.125 L/min., water pressure: 14 PSI (± 2); vacuum levels: 500 mm/Hg, displacement/air leakage: 200 L/min, power consumption: 1650 W ($\pm 10\%$), power frequency: 50/60 Hz) and a conventional dental suction system (Venturi®; Dabi Atlante, Ribeirão Preto, SP, Brazil; air consumption: 9 L/min., water consumption: 0 L/min., mains: supplied by dental chair, power consumption: 24 W, power frequency: 50/60 Hz). Two types of suction tips were used with each suction system: a conventional saliva ejector and a conventional saliva ejector customized by the adaptation of a 55-mm-diameter funnel. The saliva ejector-funnel interface was involved with insulating tape to provide complete sealing.

PrepStar™ air-abrasion unit (Danville Engineering, San Ramon, CA, USA) was used at 80 psi with an angulated active tip (80° angle) with internal diameter of 0.48-mm.

The experiment was conducted in a dental office with an area of 25 m². All access ways, such as doors and windows, were shut and the air conditioner had the flaps set in a straight position. A metallic clamping device was fixed at the dental chair head to serve as a brace for securing a phantom head. This device had five horizontal shafts, corresponding to each operator's clock-related working positions (9, 11, 12, 1 and 3 o'clock)⁸, and one vertical shaft to simulate the operator's nasal cavity, in addition to two articulated arms that held the handpiece of the air-abrasion device and the suction system.

To simulate the patient's position, as well as the dentist's and assistant's working positions, the dental chair was set at a 45° angle and 40 cm above the floor.

The operative field was delimited by the 6 shafts (each measuring 75 cm in length), with marks every 5 cm. The shafts were horizontally displayed in a 180° radius at a distance of 36° between each other. Five-millimeter-diameter plastic supports were attached to the shafts at distances of 20, 40 and 60 cm from the center of the oral cavity of the phantom head. Petri plates (Bioplass®; PlastLabor, Rio de Janeiro, RJ, Brazil) were fixed to the supports to collect the aluminum oxide particles spread over during air abrasion (Figure 1).

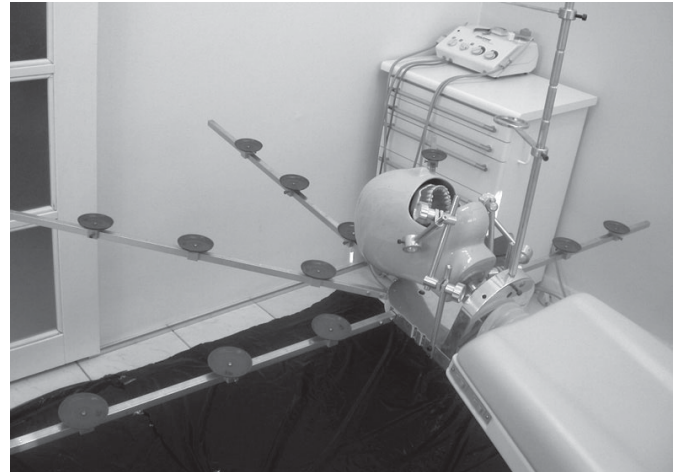


Fig. 1. Device to collect the aluminum oxide particles spread over during air abrasion

Cavities were prepared in a posterior tooth fabricated from self-curing acrylic resin (Duralay Reliance Dental Co., Chicago, IL, USA) and isolated with a rubber dam (Madeitex®, São José dos Campos, SP, Brazil) and a #26 clamp (Ivory®, Heraeus-Kulze, Hanau, Germany). The active tip of the air-abrasion unit was positioned 2 mm from the occlusal tooth surface and the aluminum-oxide particle stream was applied for 15 s. The suction system was positioned on the opposite side.

The amount of aluminum oxide particles deposited in the Petri plates was calculated based on the mass difference of each plate. For such purpose, the Petri plates were previously smeared with vaseline and weighed in a precision balance (Mettler AE 163; Quality Lab Excess, Inc., Muskegon MI 49442, USA) to obtain the initial mass. After air abrasion of the artificial tooth, the Petri plates were reweighed and final mass was obtained. The mass corresponding to the aluminum oxide particles collected during the abrasive procedure was obtained by calculating the difference between the final and the initial masses.

For each of the four possible combinations of air suction system and suction tip, there were 18 Petri plates held by plastic supports attached to the metallic shafts (3 plates *per* shaft). Each air-abrasion procedure was repeated 5 times, thus resulting in a total of 360 Petri plates.

Descriptive statistics of the data obtained from aluminum oxide particle mass weighing were presented using box plot graphs.

Results

The greatest amount of aluminum oxide powder was deposited on the Petri plates positioned on the nearest distance (20 cm) between the operator and the center of oral cavity. The conventional dental suction combined with the funnel-modified suction tip was the most efficient mechanism for capturing the aluminum oxide particles.

The amount of aluminum oxide powder accumulated on the Petri plates decreased significantly farther from the center of oral cavity. This reduction was always greater when the conventional dental suction was used with the funnel-

modified suction tip. Kruskal Wallis analysis showed a statistically significant reduction in the amount of particles deposited farther from the center of oral cavity ($p = 0.001$). Kruskal Wallis and Dunn *post hoc* test are shown in letters over the bars in which different letters denote statistical difference (Figures 1 and 2).

Regarding the operator's clock-related working positions, as indicated by the horizontal shafts #1 to #5, it was observed that the greatest particle accumulation occurred on the Petri plates located on shaft #1, which corresponded to the nine o'clock working position. This was more evident when the high-volume evacuation system was used associated to the funnel-modified suction tip, followed by conventional dental suction associated to the conventional suction tip and the high-volume evacuation system associated to the conventional suction tip. There was a clear reduction in the amount of aluminum oxide particles deposited on the Petri plates attached to the other shafts. Kruskal Wallis and Dunn *post hoc* test are shown in letters over the bars in which different letters denote statistical difference (Figure 3).

Discussion

Air contamination caused by different procedures carried out in the dental office has raised great concern and has prompted the continuous search for alternatives and methods to maintain the health of both dentists and patients undergoing dental treatments.

A probable cause of infection dissemination and damage to the respiratory system of dentists and auxiliary personnel is intimately related to the generation of particles, aerosols, gases and sprinkles during the dental procedures. According to Miller and Micik⁹, aerosols are liquid or solid particle suspensions spread in the air, which, after long exposure, may be inhaled and taken to the respiratory system possibly reaching the pulmonary alveoli. Harrel and Molinari¹⁰ point out that minute aerosol particles may potentially penetrate and lodge into small lung pathways, in addition to being vehicles for infection transmission.

During use of air-abrasion systems, a visible white mist is formed within the operative field. It is therefore important to learn how such particles accumulate and the best way of capturing them. The findings of this study showed that, regarding the working distance and the operator's working positions, the combination of either conventional or funnel-modified suction tips with the high-volume evacuation system yielded less effective powder evacuation during air-abrasion procedures (Figure 2). Similar results were reported by Jacks¹¹, who observed that a high-volume evacuation was insufficient for aerosol reduction, even when used in combination with a funnel-modified tip. On the other hand, Worral et al.¹² investigated the bacterial contamination during use of a sodium bicarbonate air-polishing unit and found that a high-volume evacuation system was efficient for reducing the formation of aerosol and bacterial colonies.

Regarding the operator's distance to the center of oral cavity, the area nearest to the dental chair head (20 cm) accumulated the greatest amount of aluminum oxide particles, especially when the high-volume evacuation system was used. These results are consistent with those of a previous study¹³, in which a great concentration of aluminum oxide particles was found close to the oral cavity. The proximity of this high concentration of aluminum particles of the operator highlights the importance of the use of personal protective equipment (PPE) by the dental team.

As the distance from the oral cavity increased, lesser amount of aluminum oxide particles were deposited on the Petri plates, mainly while employing the conventional dental suction associated to the funnel-modified suction tip. This fact may be explained by either the size and weight of the particles or the energy of the aluminum oxide powder stream delivered by air pressure, which may limit the distance reached by the particles.

The dentist's working position was assessed by the position of the shafts. The greatest aluminum oxide particle deposition was observed at the 9 o'clock working position (shaft #1) while employing the high-volume evacuation

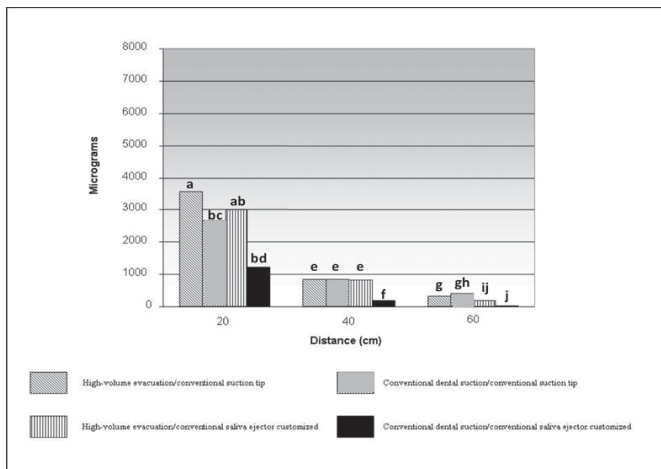


Fig. 2. Comparison between the high-volume evacuation and conventional intraoral suction systems at the distances from the center of oral cavity.

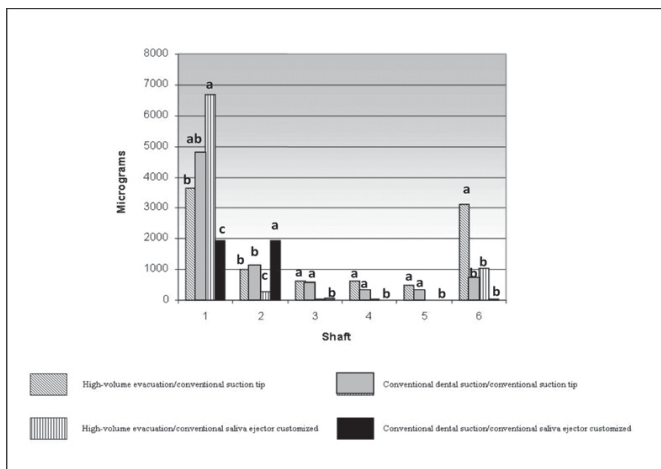


Fig. 3. Comparison between high-volume evacuation and conventional intraoral suction at the shafts simulating the operator's clock-related working positions.

system associated to the funnel-modified suction tip. This result suggests that increasing the diameter of the suction tip to 55 mm may have provided a physical barrier that acted redirecting the particle stream to the working position of a right-handed operator. The same occurs with the water spray resulting from ultrasound cooling, i.e., the water particles bounce back after getting in contact with the tooth surface¹⁴.

Unlike high-speed handpieces, sodium bicarbonate jets or ultrasound units, aluminum oxide air-abrasion devices produce a dry particle stream, which may explain the low efficiency of the tested suction systems. According to the manufacturer, these equipments are primarily intended for suction of viscous liquids and the mist produced by high-speed handpieces. Teanpaisan et al.¹⁵ has reported that a real possibility of reducing aerosol spreading within the operative field is the use of a modified extraoral suction system fabricated from a household vacuum cleaner.

Although the suction devices evaluated in this study were not able to efficaciously aspirate the powder resulting from air abrasion, the use of intraoral evacuation systems during dental procedures has been proved to reduce the risk for the operator and dental staff of inhaling both aluminum oxide particles and bacteria originated from the patient's mouth. For such purpose, adequate suction systems should be further developed.

The greatest deposition of aluminum oxide particles occurred at the shortest distance between the operator and the center of the oral cavity of the phantom head and at the 9 o'clock working position, while using the high-volume evacuation system associated to the conventional suction tip.

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